Jan. 20, 1970 E. L. NOOKER 3,490,374

CONTINUOUS ROD WARHEAD

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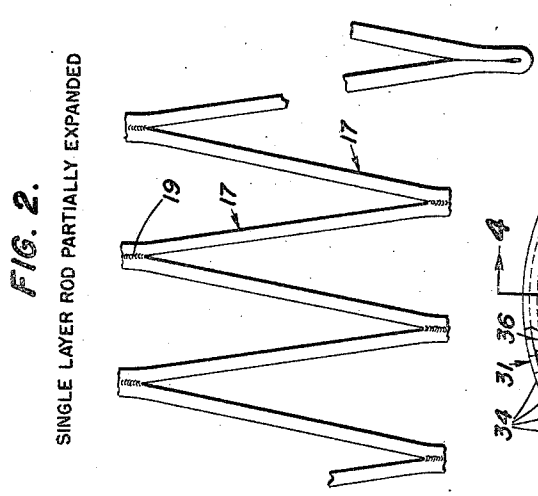

FIG. 2. SINGLE LAYER ROD PARTIALLY EXPANDED

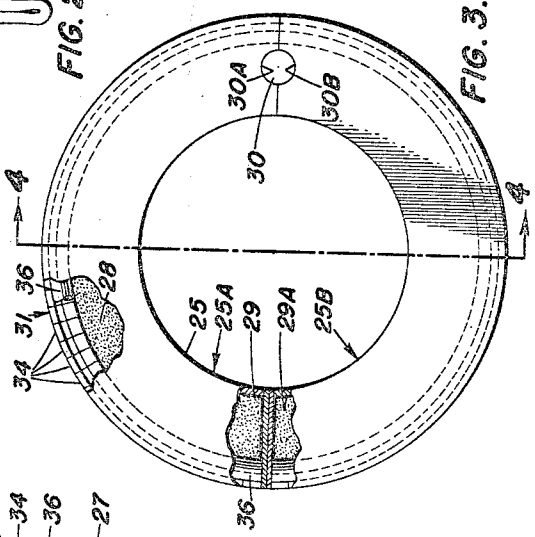

FIG. 2A.

FIG. 3.

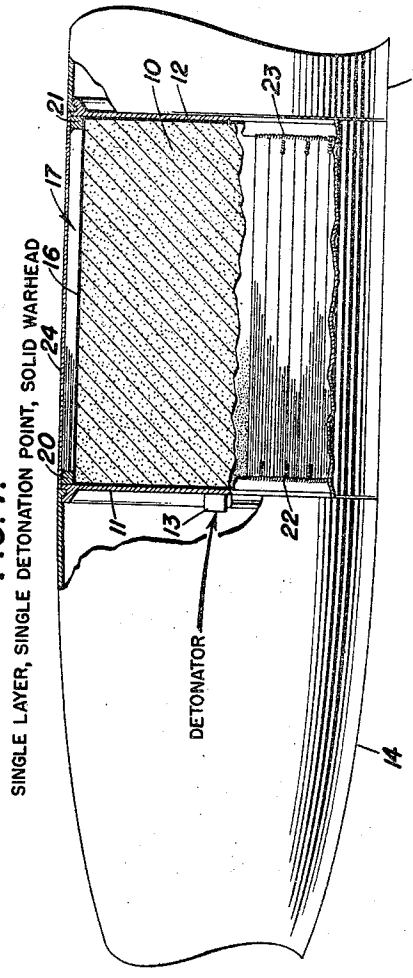

FIG. 1. SINGLE LAYER, SINGLE DETONATION POINT, SOLID WARHEAD

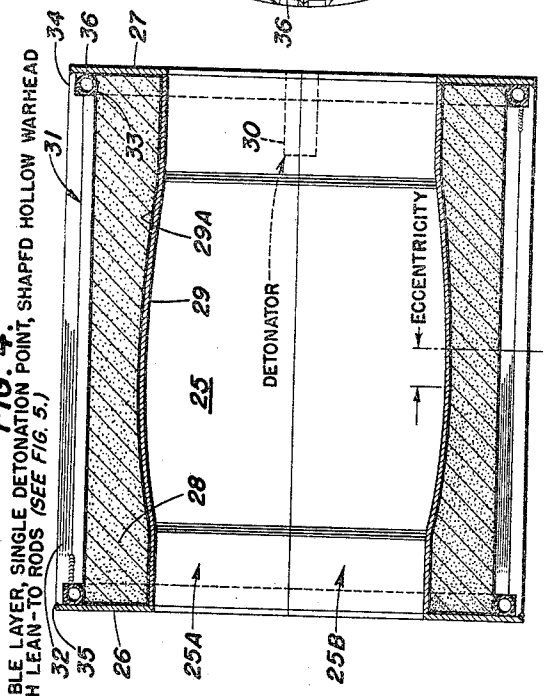

FIG. 4. DOUBLE LAYER, SINGLE DETONATION POINT, SHAPED HOLLOW WARHEAD WITH LEAN-TO RODS (SEE FIG. 5.)

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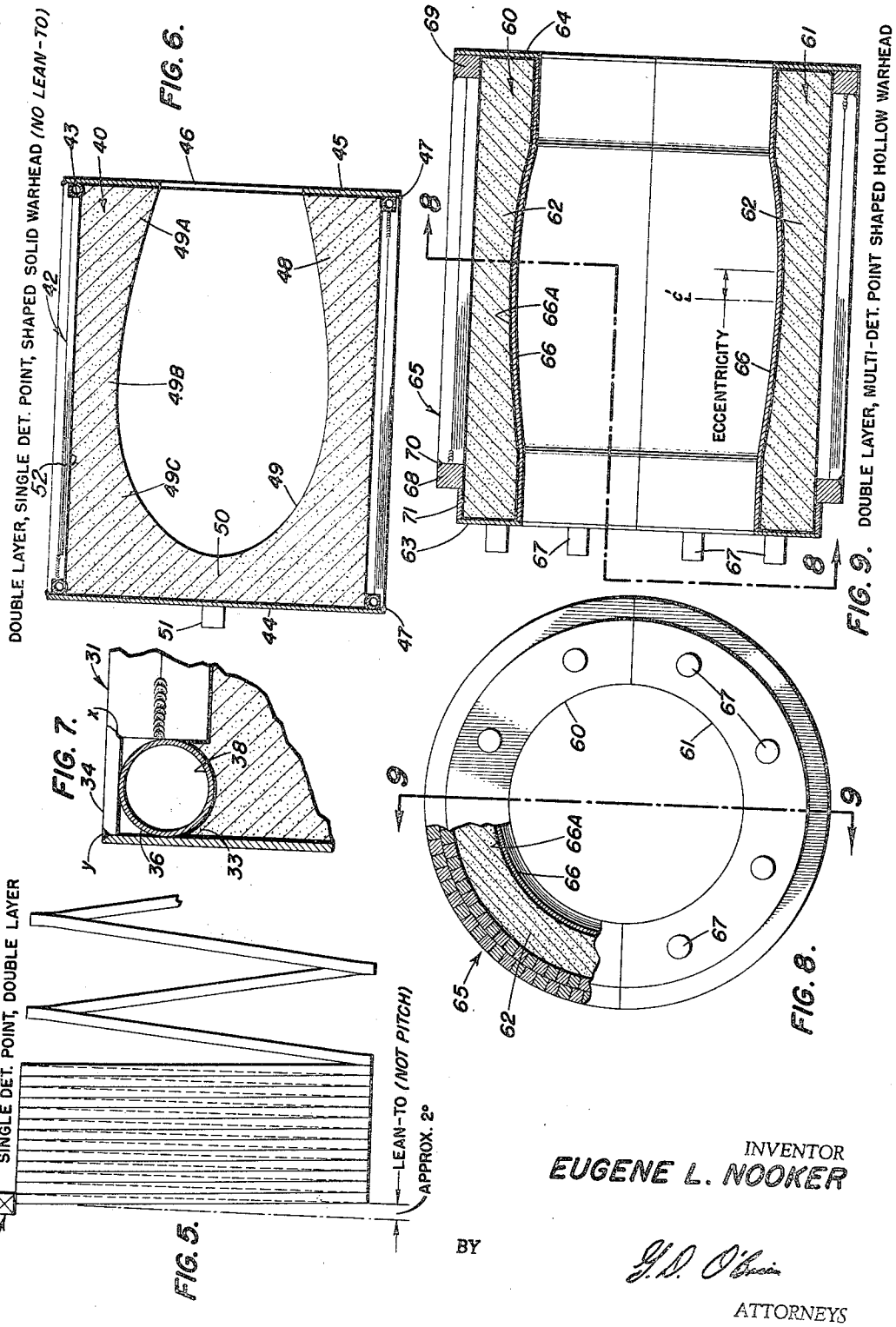

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CONTINUOUS ROD WARHEAD

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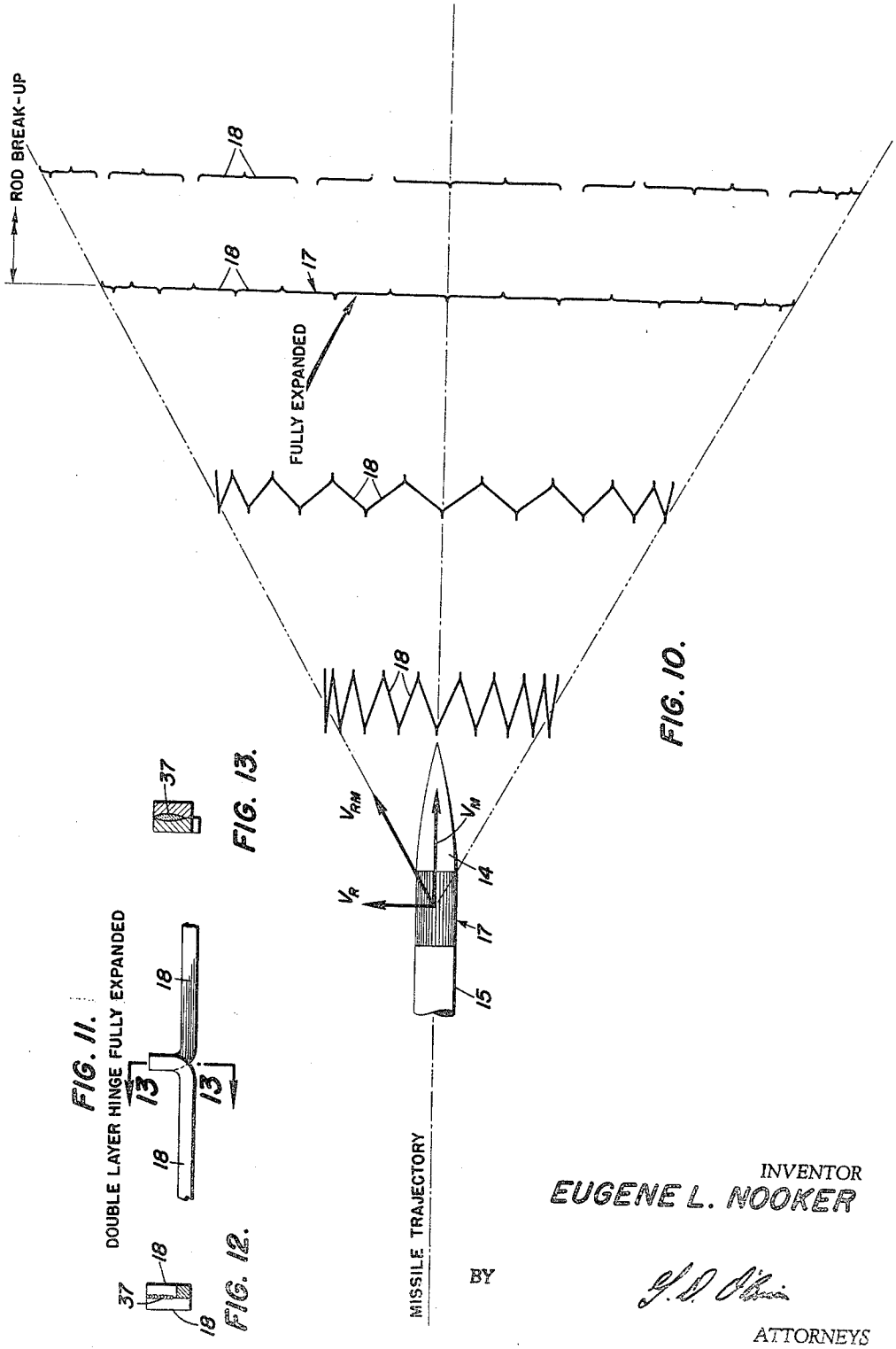

FIG. 10.

FIG. 13.

FIG. 11.

FIG. 12.

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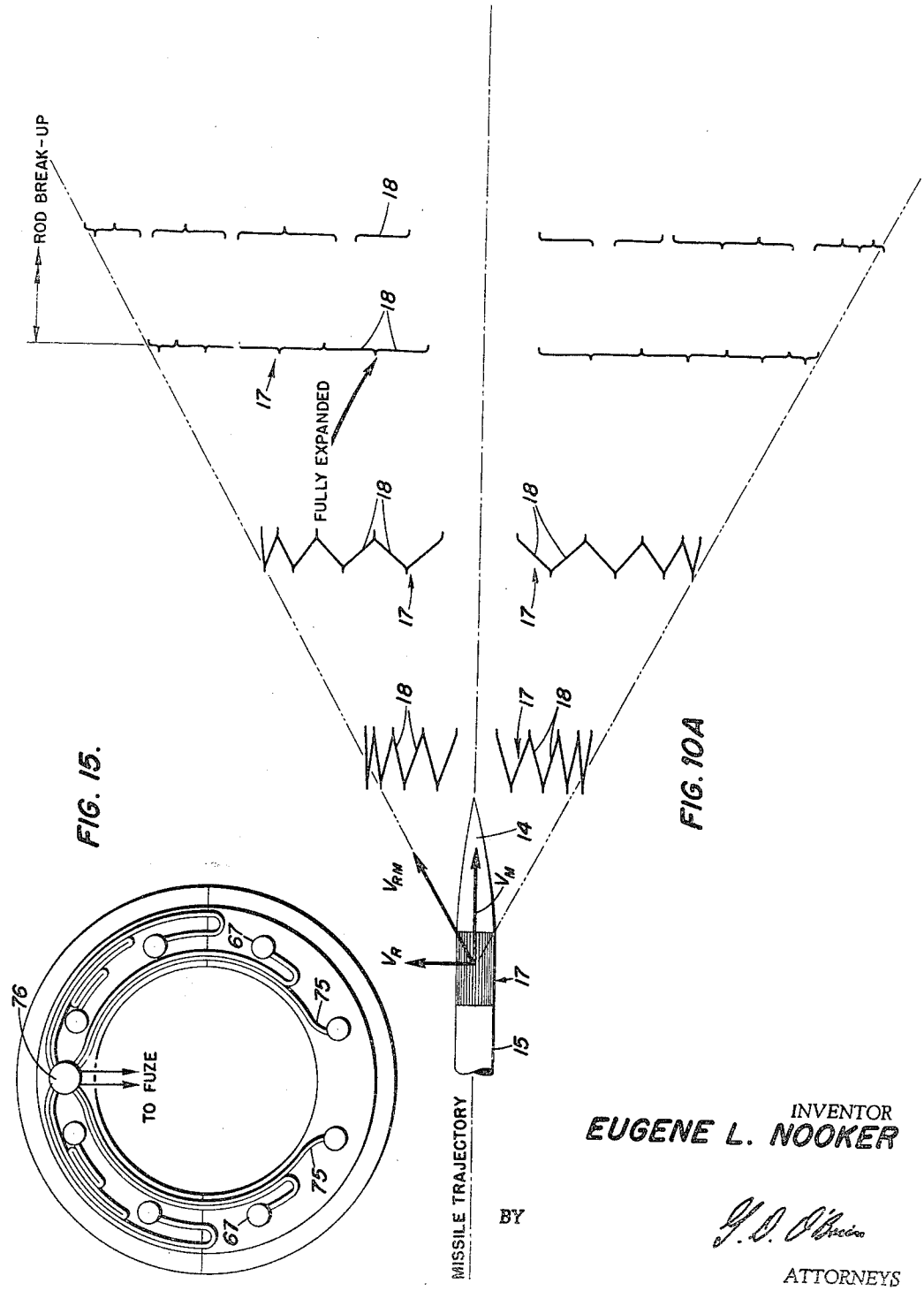

FIG. 15.

FIG. 10A

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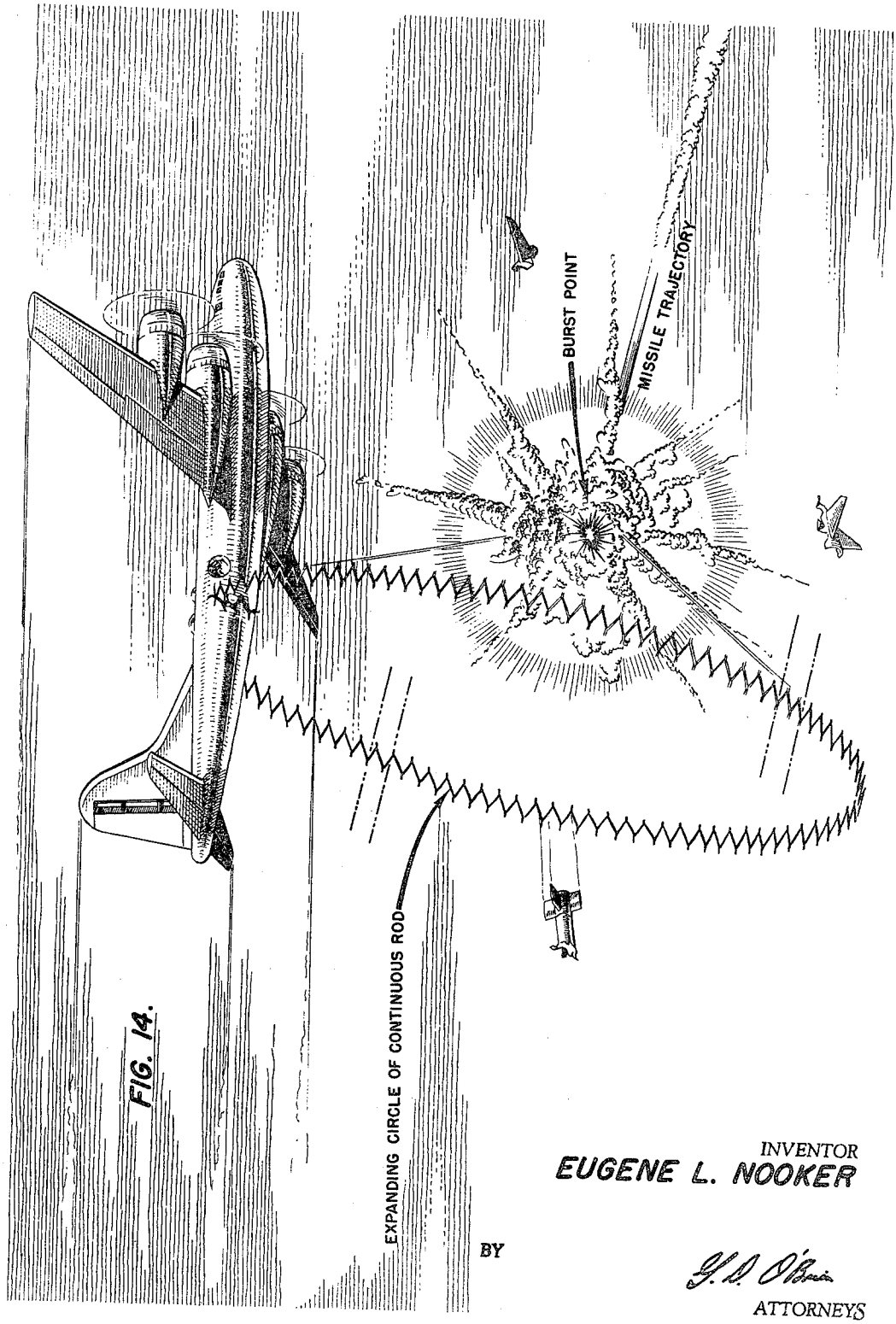

FIG. 14.

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CONTINUOUS ROD WARHEAD

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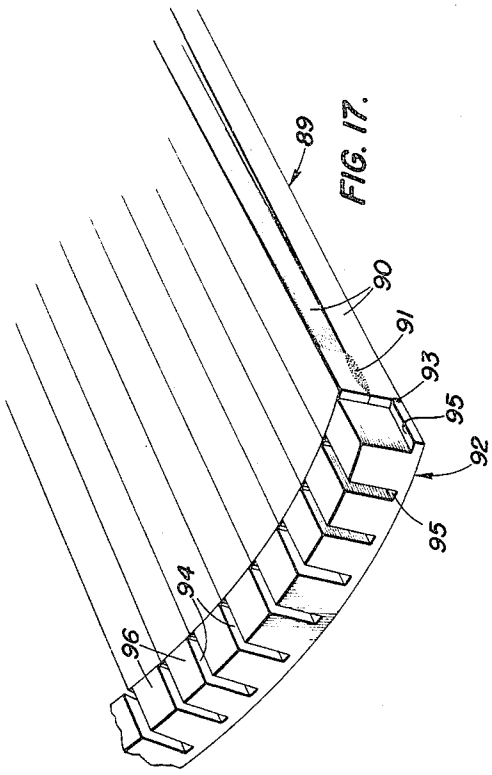

FIG. 17.

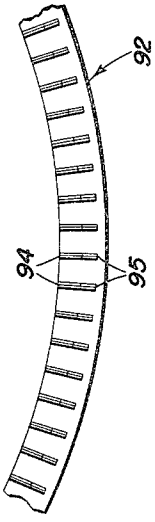

FIG. 19.

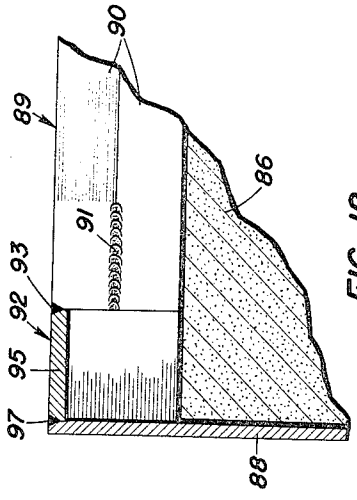

FIG. 18.

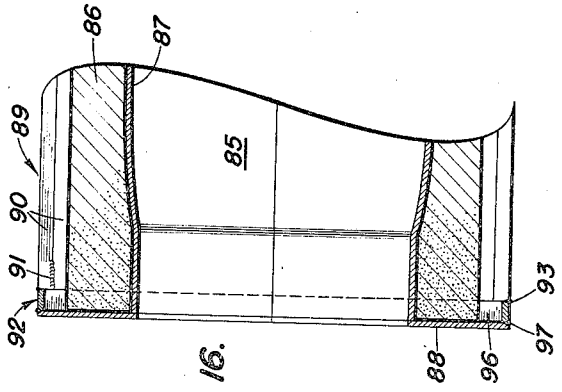

FIG. 16.

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United States Patent Office

3,490,374

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CONTINUOUS ROD WARHEAD

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Filed June 7, 1956, Ser. No. 590,078

Int. Cl. F42b *13/48*

U.S. Cl. 102—67 13 Claims

ABSTRACT OF THE DISCLOSURE

The present invention relates generally to explosive projectiles and more particularly to an improved warhead for use with aerial missiles.

Extensive studies have been made and experimental data accumulated on the effect of antiaircraft artillery shell fragments on aircraft components. The objectives of these studies were to determine the effects of fragment size, shape, velocity and composition on the ability of such fragments to damage targets, and to establish general relationships between design parameters. These studies resulted in the adoption of smaller fragments of far higher velocity than had previously been used, and indicated the need for the production of fragments of uniform size.

Following the establishment of the general principles for achieving optimum design of fragmentation warheads, the investigations were extended to include methods of target damage other than the impairment of components by fragments, including studies of internal and external blast damage with particular reference to the effects of altitude on the distances at which damage can be produced by a given charge weight.

These studies and experiments revealed that small fragments have insignificant damage effects unless they are in dense patterns or at short distances from the target where blast becomes a major factor. In view of this situation extensive studies of larger fragments were made, particularly of rectangular rods of sufficient cross section and length to sever structural elements of a target that lies in their path. These additional studies have led to the conclusion that a continuous circle of connected rods is far more effective than any dispersed pattern of discrete rods. It has been demonstrated experimentally that warheads can be made that eject connected rods at the necessary high velocities with few or no breaks in the continuity of an expanding ring until it has extended beyond its maximum circumference.

The principal object of the present invention, therefore, is to provide a warhead consisting of a plurality of connected rods, expandable at high velocity by the detonation of a high explosive charge into a continuous ring (or semi-ring) for projection into a target, for increasing the probability of destruction thereof, which said object is attained by the necessary cooperation of the mechanical, explosive and detonation systems employed. It is also an object of the invention to provide a warhead which is sufficiently compact to fit within the allotted space in the airframe of an aerial missile.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a sectional view, partially in elevation, of a warhead constructed in accordance with one embodiment of the present invention, as said warhead would appear installed in an aerial missile;

FIG. 2 is an elevation showing a fragment of the continuous rod assembly of the warhead of FIG. 1, with said rod assembly partially extended;

FIG. 2A is a detail elevation of a fragment of a continuous rod assembly formed according to a modified embodiment of the invention;

FIG. 3 is an end view of a modified embodiment of the invention;

FIG. 4 is an axial section on the line **4—4** of FIG. 3;

FIG. 5 is an elevation of the rod assembly according to one modified form of the invention, said assembly being shown with a portion thereof partially extended;

FIG. 6 is an axial section illustrating still another modified form of the invention;

FIG. 7 is an enlarged detail section of the warhead of FIG. 6, particularly showing the explosive charge shaping arrangement for effecting the separation of the rod assembly from the end caps employed, upon detonation of the warhead;

FIG. 8 is a sectional view on the line **8—8** of FIG. 9, said view partly in elevation;

FIG. 9 is a section on the line **9—9** of FIG. 8;

FIG. 10 is a schematic representation showing shapes or patterns of a warhead rod assembly for use with a unitary warhead, after detonation of the warhead, as it spreads to fully expanded and, thereafter, rod break up positions;

FIG. 10A is a view similar to FIG. 10, but showing patterns obtained with a two-piece warhead rod assembly;

FIG. 11 is a detail elevation showing one of the rod hinge connections in fully expanded position;

FIG. 12 is an end view of the hinge connection of FIG. 11, particularly showing the weld;

FIG. 13 is a section on the line **13—13** of FIG. 11;

FIG. 14 is a perspective view showing the effect of a fully expanded warhead on the fuselage of an airplane, following the explosion of a missile mounting the warhead of the present invention, in the vicinity of said airplane;

FIG. 15 is a schematic view showing primacord and electrical connections for a multiple detonator warhead of the type shown in FIG. 8;

FIG. 16 is a detail section showing a warhead constructured according to FIG. 4 but incuding a modified end hoop structure;

FIG. 17 is a detail perspective view of the modified end hoop structure welded to ends of rod elements;

FIG. 18 is an enlarged detail section of the modified end hoop structure arranged in operative relation to the rod elements and an end plate; and

FIG. 19 is a detail end view of the modified end hoop structure.

In order to obtain a better understanding of the present invention, a brief discussion of the background which led to its development is thought to be in order.

Of the several means of "killing" (destroying) an aircraft, a direct attack on its airframe offers three special advantages, i.e. (1) the airframe is the largest component of the aircraft; (2) unlike most other components it cannot readily be protected; (3) the results of most rounds are immediately apparent; that is, complete and almost instantaneous destruction is usually effected.

Against small aircraft, fragments of substantial size or rods 1 to 2 feet long, if approaching from certain directions, are capable of producing destruction. Against the structure of larger and more modern aircraft, however, it has been established that unless cuts several feet long are made, the kill probability can be extremely low. That is, it is necessary to cut from ⅔ to the full length of the structural face; generally stated, if the design load factor is 4, then ¾ of the structure must be severed.

It has been found difficult to produce long cuts in heavy structure, such as exists in a modern heavy airplane, with discrete rods no longer than two feet, because random motion of individual rods results in only a small percentage of effectiveness of the total rod length at the point of target intersection. To make long cuts, either the rods must be oriented on the target in such a manner that several rods contribute to an essentially single cut, or long rods must be used. Although the desirability of long rods is clearly recognized, their practical value as a weapon has been discounted, because maximum discrete rod length is necessarily limited to warhead length. The present invention overcomes this limitation by providing a warhead including a plurality of individual rod elements connected to produce a single, endless folded rod which, upon detonation of the warhead, unfolds into an expanding circle. Ideally, this circle remains unbroken until nearly total rod length is reached and after target intersection is attained. If break up into random lengths should occur before target intersection takes place, however, the target kill probability will remain high if lengths of substantial size intersect it.

The warhead constituting the present invention, as shown in FIGS 1 and 2 (in its basic form), includes a bursting charge **10** which is confined between end plates **11** and **12**. The charge **10** may conveniently be black powder, and a detonator **13** for said charge is mounted axially of the end plate **11**. The warhead is shown mounted in an aerial missile, portions of which are illustrated at **14** and **15**. The diameter of the charge **10** is slightly less than that of the end plates **11** and **12** for defining a shallow annular chamber, the purpose for which will become apparent hereinafter. Completely enveloping the charge **10** is a coating **16**, of thermoplastic material, for protecting the charge from shocks incident to handling.

Mounted in the chamber and overlying the coating **16** is a rod assembly which is shown generally at **17**, and which defines a projectile. The rod assembly is formed of a plurality of rod elements **18**, each of rectangular cross section, laid side by side and connected at alternate ends so as to form a cylinder. As best seen in FIG. 2, the ends of the rods are secured by substantial welds **19**, and the asssembly is retained in cylindrical form by end hoops **20** and **21** which are secured to opposite ends of the rod elements by running welds **22** and **23**. As shown in FIG. 2A, the rod assembly may be constituted by a single rod with end portions folded, in lieu of individual rod elements with their end portions welded. An outer covering or skin **24** surrounds the assembly and preserves the unbroken outer contour of the missile.

In operation, upon initiation of the detonator **13**, by the functioning of an influence fuze mechanism or the like (not shown), the charge **10** is exploded, whereupon the forces created by said explosion will cause breaking of the running welds **22** and **23** and releasing of the rod assembly **17** from between the end hoops **20** and **21**. The forces of the exploding charge will cause the rod elements to unfold, in the manner shown in FIG. 2, into a continuous ring which functions as a projectile. The manner of unfolding will best be understood after a study of FIG. 10 of the drawings. Experimental firings of warheads made according to FIGS. 1 and 2 of the drawings have occasionally resulted in separation of some of the rod elements forming the circle of rods. However, such separation has rarely caused all of the rod elements to separate from each other, and two or more connected rods constitute a lethal missile when striking a target. Experiments with various types of connections for the ends of the rod elements resulted in the determination that, for the embodiment of the invention shown in FIGS. 1 and 2, the welds **19** were the most successful.

Rod elements of the type shown at **17** are relatively large in cross section (say ½") and therefore result in a projectile having, in its fully projected position, a relatively small diameter with consequent reduced lethality. Such projectiles, moreover, lost rod element continuity when subjected to velocities in excess of approximately 2000 ft./sec. and were therefore not suitable for use with supersonic guided missiles. This loss of continuity was brought about by forces which, upon bursting of the charge **10**, moved radially from the warhead axis (and thus at slightly divergent angles) and tended to destroy the hinges at the welds **19**.

Experimental work revealed that a projectile having adequate rod continuity and greater destructive power could be made if a larger number of rod elements were used. Necessarily such rod elements had to be of smaller cross section if the warhead were to be placed in the allotted space in the missile. Very high power explosives were needed with the smaller rods, however, in order to impart to the rod elements the velocities necessary to produce a lethal warhead. Accordingly, a projectile was developed consisting of a rod assembly wherein each pair of connected ends of rod elements was positioned in a radial plane instead of in a tangential plane, so that, for a given pair of rod elements, explosive forces acted on the connected end portions of said elements along the same radii rather than at slightly different radial angles, with the result that the rod elements received their propulsive forces simultaneously, and the hinges connecting the elements were not subjected to forces which would tend to effective separation of said elements. Such a rod assembly consists of two layers of rod elements rather than one layer and is shown in FIGS. 3 and 4 of the drawings.

The embodiment of the invention of FIGS. 3 and 4 is shown applied to a warhead for use in a ramjet aerial missile. The warhead of this embodiment is shown generally at **25** and consists of companion hollow semi-cylindrical sections **25A** and **25B** each having end plates **26** and **27**, a high power explosive charge **28**, a liner **29**, a rod assembly defining a projectile, and a thermoplastic coating **29*a*** for the charge. A single detonator **30** is positioned at one end of the warhead, in companion recesses **30*a*** and **30*b*** formed in meeting faces of the sections **25A** and **25B**. Thus, a single detonator suffices to explode the charge **28** in each of said sections. For a reason to be pointed out hereinafter, the explosive charge **28** is reduced in thickness between its midpoint and its end most remote from the detonator **30**.

The numeral **31** indicates generally the rod assemblies of this embodiment of the invention. Each rod assembly **31** consists of inner and outer layers of rod elements **32** having alternate ends of individual rod elements so attached by welding that said assembly will, when projected by explosion of the charge **28**, assume the shape of an unbroken half-ring.

As best seen in FIG. 5, the rod elements **32** of each rod assembly **31** are mounted at an angle of approximately 2° from an element of the cylinder constituted by the warhead, which angular mounting will be referred to hereinafter as "lean-to," for convenience. The lean-to is in the direction of the single detonator and is for the purpose of equalizing the ejection angles of successive rods following detonation of the warhead by a high explosive charge, so that they will move uniformly and without inter-rod interference in the same direction when the detonator is exploded.

Referring again to FIGS. 3 and 4, it will be seen that the opposite end portions of the rod elements **32** are cut to define annular recesses **33** and, as to the outer layer of rod elements, end tabs **34**, said end tabs being welded, at **35**, to the end plates **26** and **27**. Positioned in each of the recesses **33** of each warhead section is a semi-circular spalling tube **36**, the operation of which will be explained hereinafter. Assembly of a warhead constructed in accordance with this embodiment of the invention is effected by the welds **35**. More specifically, after the spalling tubes **36** have been placed in their respective recesses **33**, the end tabs **34** are secured to the end plates **26** and **27** by

the welds **35**, for retaining the rod assembly, end plates, said tubes, liner **29** and explosive charge as a unitary structure.

In order to form the two layers of rod elements as shown in FIGS. 3 and 4, the alternate end portions of adjacent rods are positioned and secured in overlapping relation by welds **37**, as shown in FIGS. 12 and 13. The actual welding process forms the subject matter of a separate patent application and therefore constitutes no part of the present invention. To permit installation in an appropriate space of a ramjet missile, the companion sections of the warhead are separated and fitted together in such space, with their outer surfaces lying flush with the outer surface of the missile. As best seen in FIG. 3, the single detonator **30** is mounted in companion arcuate recesses in corresponding ends of the warhead sections.

In operation, when the detonator **30** is exploded, by an influence or impact exploding device (not shown), the charge **28** in the sections **25A** and **25B** will be exploded for breaking the opposite ends of the rod elements **17** from their respective end plates **26**, **27** and propelling the said elements outwardly as a pair of semi-circular projectiles. The appearance of the projectiles during propulsion thereof toward a target would be somewhat as shown in FIG. 10A.

Considered in greater detail, the projection of the rod elements in a manner to form semi-circular projectiles is accomplished by the simultaneous or nearly simultaneous occurrence of several effects, viz., the breaking away of the ends of the rod elements **17** from the end plates; the application of explosive contouring to equalize the forces applied to the rod elements throughout their lengths to minimize tumbling and bending of said elements; and the application of explosive forces to each pair of rod elements at a slightly different radial angle from its next adjacent pair of elements.

To cause the explosive forces to project radially at the ends of each of the explosive charges **28**, semi-annular grooves **38** are formed in said charges. The grooves **38** receive portions of the spalling tubes **36**. Thus, when the charges **28** are detonated, explosive forces will move radially outwardly and will cooperate with stress waves moving transversely and lengthwise of the rod elements **17** for effecting the breaking of the tabs **34**, substantially at the points indicated by the line X in FIG. 7. Breaking of the tabs at the points Y (FIG. 7) will also be effected, in all probability. Separation of the ends of the rod elements from the tabs **34** will take place when the internal reflected tension stresses thereon are greater than the dynamic ultimate strength of the material of which said tabs are formed. As best seen in FIG. 4, the charges **28** in the sections **25A** and **25B** are shaped by varying their thicknesses from near their midpoints to their corresponding opposite ends. The areas of maximum shaping are located short distances from a center line passing through said sections normal to the warhead axis and in the portions of said sections which are remote from the portions carrying the detonator. The exact locations of the areas of maximum shaping depend upon the variation of explosive power of the explosive charge with the length of the rods, and the extent of the mechanical and explosive effects at the rod ends. The purpose of the shaping of the charges is to impart uniform explosive forces to the rods of the rod assemblies along their lengths, so that bending and tumbling of the rods will be held to a minimum.

It is desired to point out that the liners **29** are needed only in connection with the casting of the explosive charges and to provide a psychological safety factor when handling; they are not requisite for warhead operation.

Referring now to the embodiment of the invention disclosed in FIG. 6 of the drawings, the numeral **40** designates a warhead which is generally similar to the warhead disclosed in FIG. 1, the principal differences residing in the use of a shaped charge and a multiple-layer rod assembly projectile. The rod assembly is shown at **42** and is identical to the rod assembly **31**. Spalling tubes **43** are shown in recesses at the ends of the rod assembly and serve the same purpose as the tubes **36**. Unlike the tubes **36**, which are semi-circular, the spalling tubes **43** are circular, since this embodiment of the invention is not of sectionalized construction. If desired, end hoops similar to those shown at **20** in FIG. 1 may be substituted for the tubes **43**.

Closing the ends of the warhead of FIG. 6 are end plates **44** and **45**, the plate **45** having a central opening **46** therein. The end plates are secured to the end tabs of the rod assembly by running welds **47**, to provide a unitary structure. Contained within the hollow body defined by the rod assembly and the end plates is a high explosive charge **48** which is shaped by the provision of a substantially pear-shaped recess **49**. The recess **49** defines a relatively thick end portion **49*a*** adjacent the end plate **45**, a relatively thin central portion **49*b***, and a relatively thick end portion **49*c*** which merges into an end portion **50** covering the inner surface of the end plate **44**. Annular grooves, similar to the groove **38** in FIG. 7 and for the same purpose, are formed in the outer wall of the charge **48**, near its ends, to receive the spalling tubes **43**. A single detonator **51** is mounted on the end plate **44**, for ignition by a suitable fuze (not shown). A coating **52** of thermoplastic material surrounds the charge **48**, for the same purpose as that of the coatings **16** and **29*a***.

Ignition of the detonator effects the explosion of the high explosive charge **48**, for projecting the rod elements as a continuous ring-like projectile, in the manner shown diagrammatically in FIG. 10. The shaping of the explosive charge **48**, by providing the relatively thick end portions **49*a*** and **49*c*** and the relatively thin central portion **49*b***, directs the maximum explosive power toward the opposite ends of the rod assembly simultaneously, with the result that rod bending and tumbling will be reduced to a minimum. The grooves cooperate with the spalling tubes for forming localized shaped charges, as shown in FIG. 7, for breaking the end tabs of the rod assembly and freeing said assembly from the end plates **44** and **45**.

The modified form of the warhead, illustrated in FIGS. 8 and 9, is similar to the embodiment shown in FIGS. 3 and 4, to the extent that a two-section, shaped charge construction is employed. In the structure of FIGS. 8 and 9, however, a multiple detonator arrangement is used, the spalling tubes are dispensed with, and no lean-to is needed for the rod elements. In FIGS. 8 and 9 the semi-cylindrical sections are shown at **60** and **61**. Each of said sections includes a semi-cylindrical shaped charge of high explosive **62**, semi-circular end walls **63** and **64** and a rod assembly **65** which defines a projectile. Liners **66** and coatings **66*a*** similar to the liners **29** and coatings **29*a***, are also provided for each section, as is a plurality of detonators **67**, said detonators being arranged in a spaced series on the end wall **63** (four detonators being shown for each section).

As in the embodiment shown in FIGS. 3 and 4, the charges **62** in the sections **60** and **61** are shaped by forming them with relatively thin portions offset from their midpoints away from the detonators, the distance from a center line passing through the warhead axis normal thereto to a line passing through the points of maximum thinness being called the eccentricity dimension, for convenience.

The rod assemblies **65** each consist of a double layer of connected rod elements somewhat similar to the rod elements **32** of the assemblies **31**, the principal differences residing in the omission of the end tabs and the substitution of semi-circular end hoops for the spalling tubes **36**. The end hoops, of rectangular cross section, are shown at **68** and **69** and are secured to the ends of the rod elements by running welds **70**.

As best seen in FIG. 9, the end wall **64** is extended radially to define a flange which has bearing thereagainst the end hoop **69**. The end hoop **68**, however, extends about the charge **62** in spaced relation to the end wall **63**. A band **71** surrounds the charge between said wall

63 and the end hoop 68, to protect the end portion of said charge and to space the projectile 65 from the detonators. The spacing of the projectile from the detonators permits the explosive wave, initiated by the firing of said detonators, to build up to a maximum force as it moves from the point of detonation along said charge.

As in the embodiments of the invention shown in FIGS. 3, 4 and 6, the shaping of the charges 62 has the effect of projecting the maximum explosive forces thereof at the ends of the projectiles 65, to break the welds between the end hoops and the rod elements and also to prevent bending and tumbling of said rod elements. Detonation of the charges 62 is effected by the simultaneous initiation of the detonators 67 by a suitable fuze device (not shown), such detonation resulting in the projection of the rod elements in the sections 60 and 61 as semi-circular projectiles, generally in the pattern shown in FIG. 10A. In FIG. 15 there is shown schematically an arrangement for initiating the detonators, by a plurality of equal-length primacord elements 75 one such element being connected to each detonator and the ends of all of the primacord elements remote from the detonators being connected to an electrically detonatable squib 76 which is, in turn, connected in the missile fuze firing circuit (not shown).

Referring now to FIGS. 16 through 19 of the drawings, illustrating a modified end hoop construction, a portion of a ramjet type warhead is shown at 85, including a contoured explosive charge 86, a liner 87, an end plate 88, and a projectile assembly 89 including rod elements 90 connected by welds 91. In lieu of the end tabs 34 shown in FIGS. 3 and 4, an end hoop 92 is secured, by a running weld 93, to the end faces of the rod elements 90. As shown in detail in FIGS. 17 and 18, the end hoop 92 is formed with a series of spaced slots 94 which extend from the inner wall of said hoop throughout substantially five-sixths of its thickness to define weakened portions or webs 95. The slots 94 and webs 95 define blocks 96 each one of which confronts the end faces of a pair of rod elements 90, the said slots being in the planes of the adjacent side walls of pairs of the rod elements. The end plate 88 is secured to the outer surface of the hoop 92 by a running weld 97.

In operation, detonation of the charge 86 will effect breaking of the hoop 92 at the webs 95, and the breaking away of the end plate 88 from the hoop. In actual practice it has been found that some of the blocks 96 may remain attached to their adjacent rod element end faces. In all other respects the operation of the warhead will be similar to that of previously described embodiments.

It is desired to emphasize that, with respect to all embodiments of the invention, a successful continuous rod warhead requires that a number of criteria be satisfied, i.e., all of the following features must be present; effective, cooperating mechanical, explosive and detonation systems. The mechanical system must comprise satisfactorily designed rod hinge and rod end structures, all manufactured to close tolerances. The explosive system must be so designed that the explosive impulses applied to the rod elements throughout their lengths will be controlled. The detonation system must provide for controlling the detonation wave, i.e., axially with a multipoint system, and with lean-to, as previously described, with a single detonator.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings.

What is claimed is:

1. In a warhead having a detonating explosive charge, a projectile including a plurality of rod elements initially arranged in side-by-side relation about the charge, said rod elements having only their alternate opposite end faces rigidly interconnected to adjacent rod elements whereby upon explosion of the charge the detonation wave produced thereby will cause said elements to bend away from each other at points near their connected end portions and project as a continuous ring.

2. In a missile warhead having an explosive charge, an elongated metallic member shaped to form a cylindrical projectile surrounding the charge, said projectile consisting of a plurality of rod elements initially folded upon themselves at their alternate opposite ends but being bendable at points near their folded portions by explosive forces upon detonation of the charge to assume substantially ring-like configuration.

3. In a missile warhead, a projectile to be subjected to detonating explosive forces, said projectile including a plurality of rod elements having only their alternate opposite end faces rigidly connected to adjacent rod elements and initially arranged in parallel relation but extensible by said detonating explosive forces to substantially ring-like configuration, and end hoops engaging the ends of the rod elements for retaining them in said parallel relation prior to their extension into said ring-like configuration.

4. In a missile warhead, a plurality of rod elements having only their alternate opposite end faces rigidly connected to adjacent rod elements and initially arranged in parallel relation, end hoops engaging the rod elements at their ends for retaining said rod elements in said initial parallel relation, an explosive charge adjacent the rod elements and operable upon detonation for producing a detonation wave for breaking the ends of the rod elements from the end hoops, the forces produced by said detonation wave causing the elements to bend away from each other at points near their points of rigid connection and be propelled as a projectile having substantially arcuate contour, and end plates secured to the end hoops.

5. In a missile warhead, a plurality of rod elements having only their alternate opposite end faces rigidly connected to adjacent rod elements and initially arranged in parallel relation, slotted end hoops secured to the rod elements and defining end blocks for retaining the rod elements in their initial parallel relation, and an explosive charge operable upon detonation for producing a detonation wave for breaking the hoops, said detonation wave forces causing said elements to bend away from each other at points near their connected portions and to be propelled as a projectile having substantially arcuate contour.

6. In a cylindrical warhead, a detonating explosive charge, a detonator for the charge, said detonator being positioned on an element of the cylinder defined by said warhead, and a projectile consisting of a plurality of rod elements having only their alternate opposite end faces rigidly connected to adjacent rod elements, the rod elements each being mounted to extend longitudinally of the warhead and having corresponding ends on the elements of the cylinder containing the detonator and confronting said detoator and opposite corresponding ends positioned at an angle to said element of said cylinder, the angular disposition of the ends of the rod elements remote from the detonator resulting in the effecting of control of the direction of travel of the rod elements upon explosion of the charge, said explosion causing said elements to spread at points inwardly from their rigidly connected ends and to project in a uniform pattern and without distortion or separation of individual rod elements.

7. In a missile warhead, adjacent projectile defining rod elements, and means anchoring ends of said elements prior to warhead detonation, said means comprising an end hoop formed with slots arranged in an annular series and defining web-connected blocks, one of said blocks confronting the end faces of a pair of adjacent rod elements.

8. A missile warhead as recited in claim 7, including additionally means for securing the end hoop to the rod element end faces.

9. In a missile warhead having an explosive charge, and a projectile comprising a plurality of rod elements

rigidly connected to adjacent rod elements only at their corresponding opposite end faces, means for retaining the rod elements in parallel relation prior to detonation of the charge, and means for securing said first mentioned means in operative relation to the rod elements, said first mentioned means being constituted by an end hoop formed with a plurality of slots defining blocks and webs between the blocks, each of said blocks being positioned to confront end faces of a pair of rod elements.

10. In a warhead including a detonating explosive charge, a rod assembly surrounding the charge and comprising a plurality of rod elements rigidly connected to adjacent rod elements only at their alternate opposite end faces thereby to define a projectile, a detonator at one end of the charge, said projectile extending to a point in spaced relation to the end of the charge carrying the detonator, and a band surrounding the charge between the end thereof carrying the detonator and the rod assembly.

11. A continuous rod warhead comprising a plurality of rod elements initially arranged in parallel relation about a detonating charge, and means rigidly connecting adjacent rod elements to each other only at their alternate opposite end faces, said rod elements being extensible by the detonation wave produced by the explosion of the charge, said detonation wave causing said elements to bend away from each other at points adjacent said means and form a propelled projectile of generally circular form.

12. In an explosive warhead, a plurality of discrete rod elements, and welds rigidly connecting the rod elements to each other only at their alternate opposite end faces thereby to define a projectile.

13. A continuous rod mat for covering a hollow element, comprising a single wire in the form of a flat coil having juxtaposed courses joined at the side edges of the coil by reverse bends, said flat coil forming a double-layer tube of a shape complemental to the surface of the hollow element to be covered with said reverse bends at the ends of the tube, a wire terminus at each end of said flat coil, and said termini secured together along an element of said tube to render the rod mat endless.

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